

The relationship between tree mortality from a pine beetle epidemic and increased dissolved copper levels in the upper Big Thompson River, Colorado.

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Background

WY2000 – WY2015 C-BT East Slope North End Water Quality Report



March 17, 2017

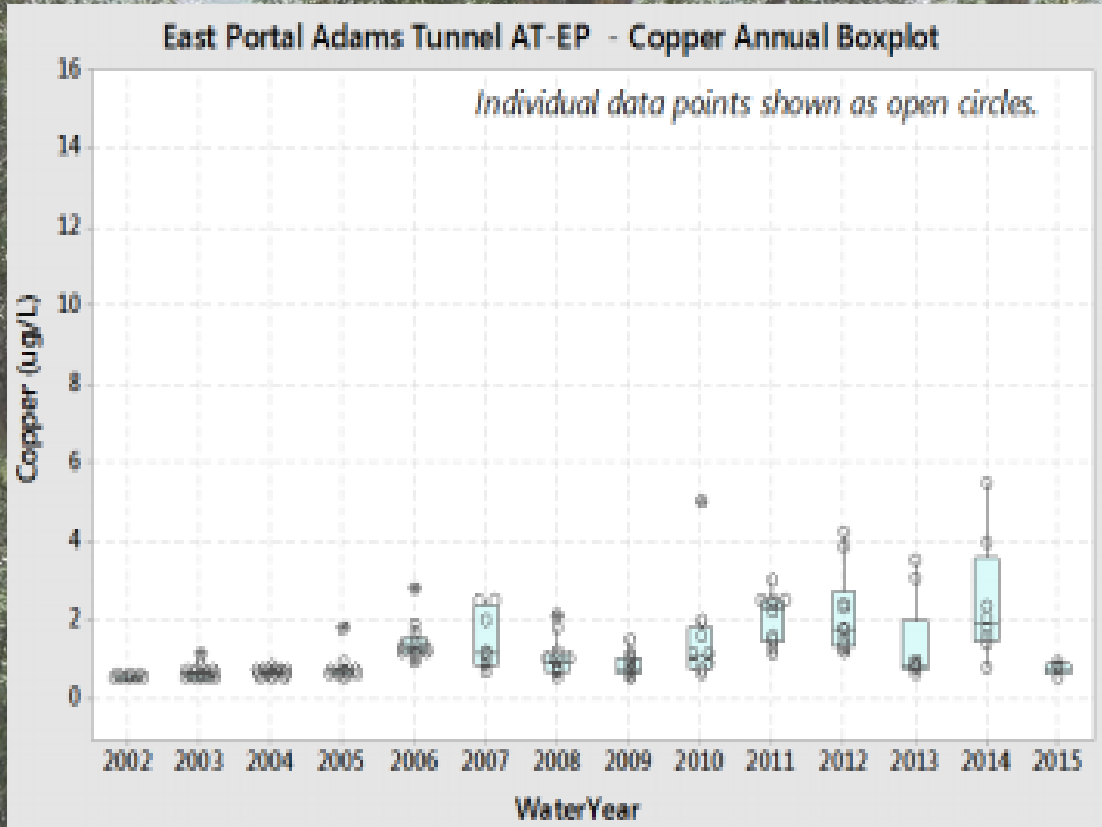


Prepared by:
Judith A. Billica, P.E., Ph.D.



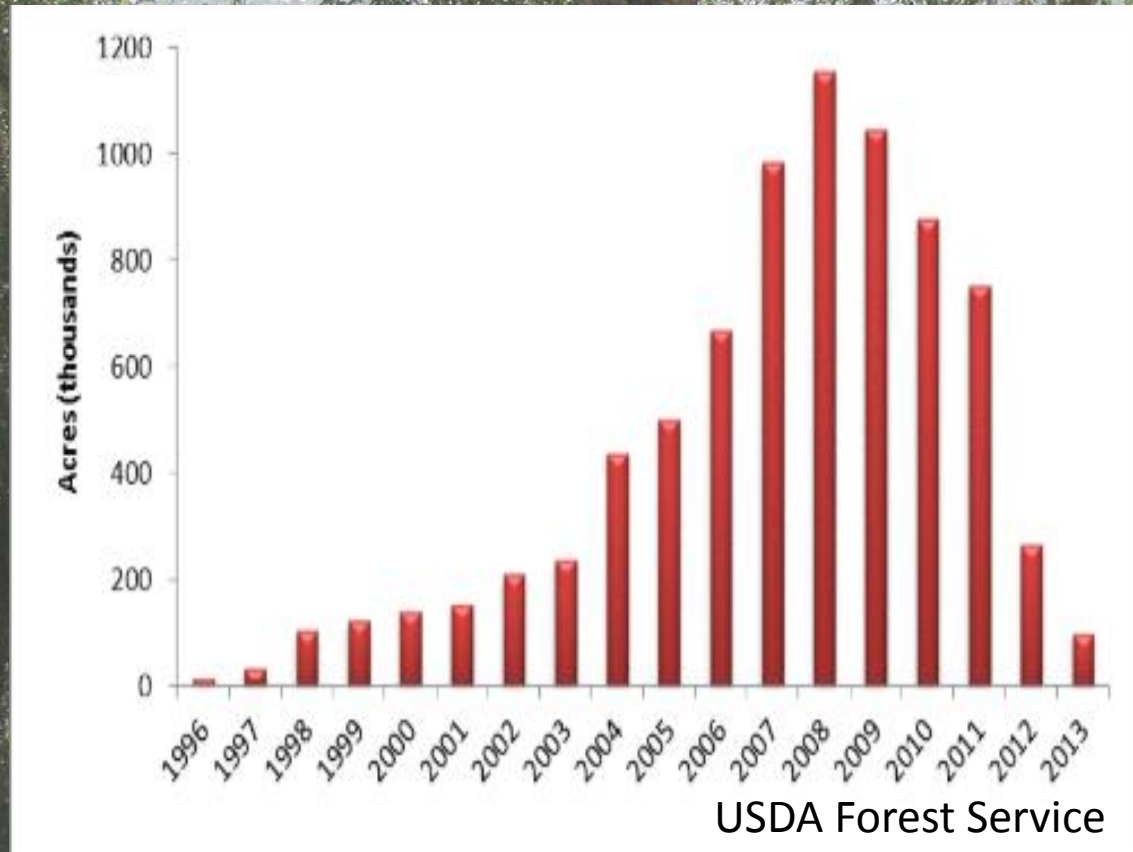
Northern Colorado Water Conservancy District
Berthoud, Colorado

Increasing Dissolved Copper in Upper Big Thompson River

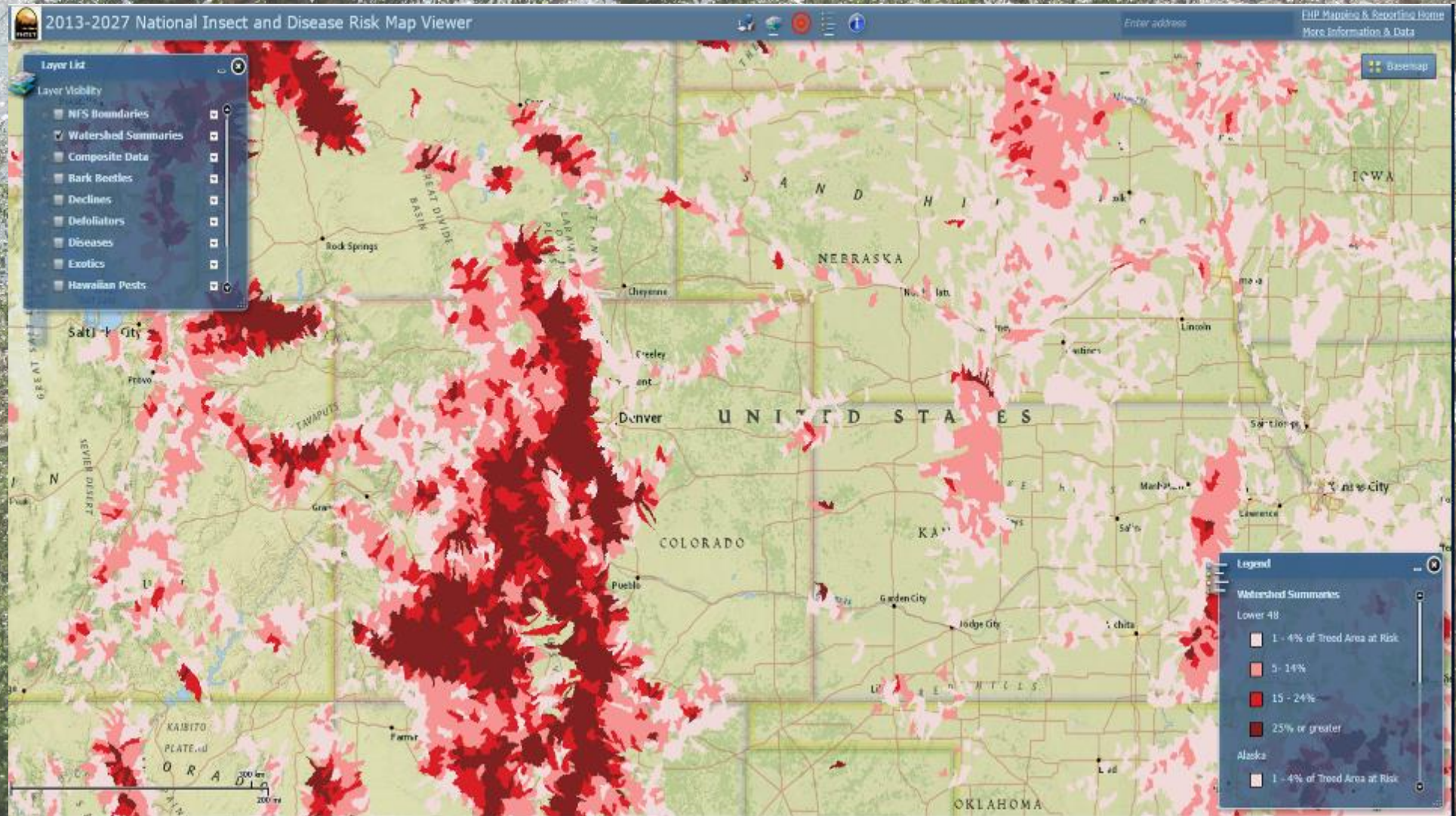


“At the Adams Tunnel and Olympus Tunnel sites, the analysis showed a statistically significant increasing trend in copper concentrations, consistent with the annual boxplots shown, for example, in Figure ES.18 for the Adams Tunnel. The cause of this increasing trend is not known.”

Acres of Damage by Mountain Pine Beetle in Colorado



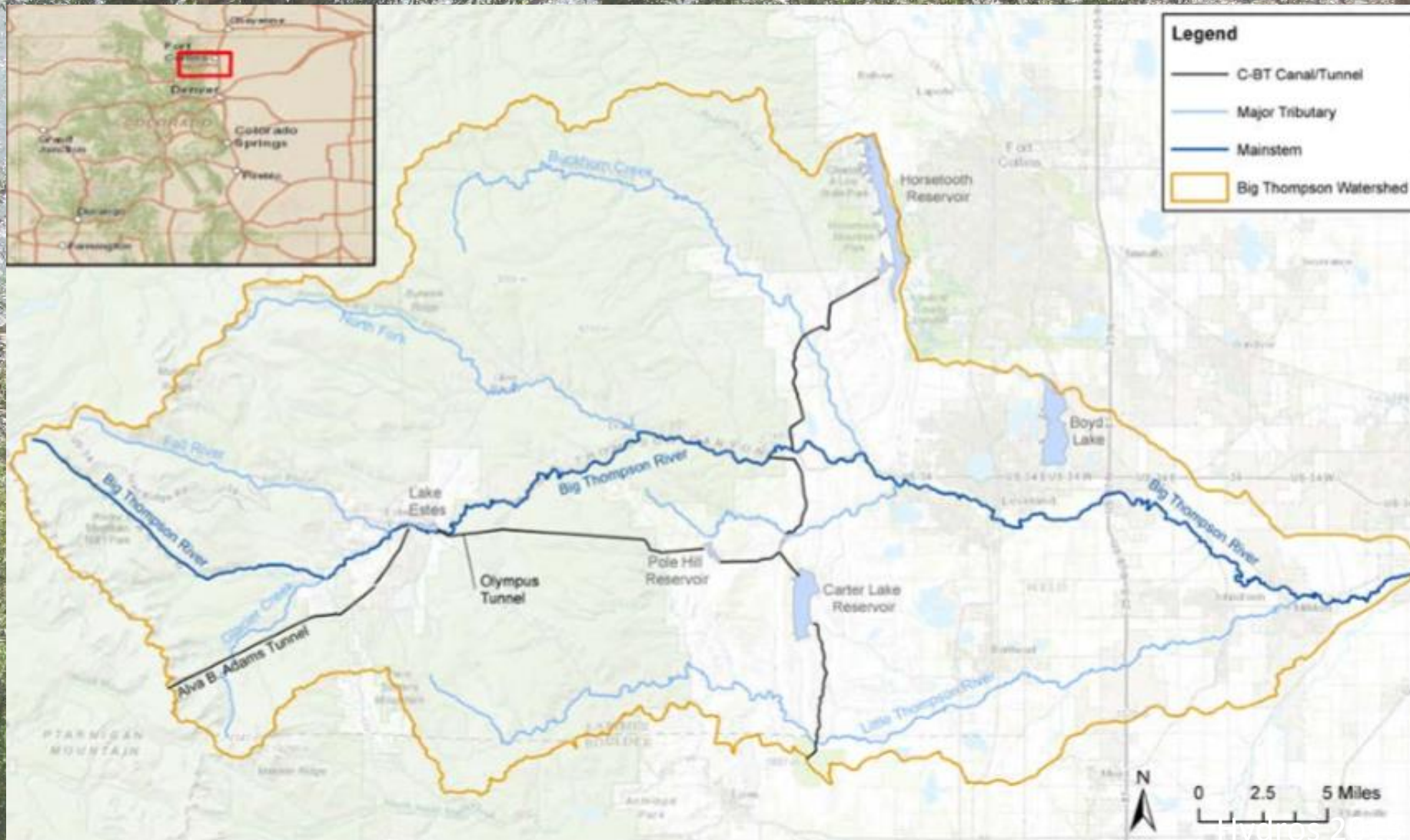
Insect and Disease Risk in Colorado



Background

1. Northern Water report documented significant increase in dissolved copper in the upper Big Thompson
2. Well documented large scale tree mortality in the Rocky Mountain West
3. Evidence for increased copper and other metals under beetle killed trees (e.g. Mikkelsen et al. 2014, Bearup et al. 2014)
 - “While unclear if manifested in adjacent surface waters, these results demonstrate and increased potential for Zn, Cd, Cu, and Al mobility, along with increased deposition of metals and carbon beneath beetle-impacted trees.” Mikkelsen et al. 2014

Big Thompson River Watershed



303d Copper Impairment



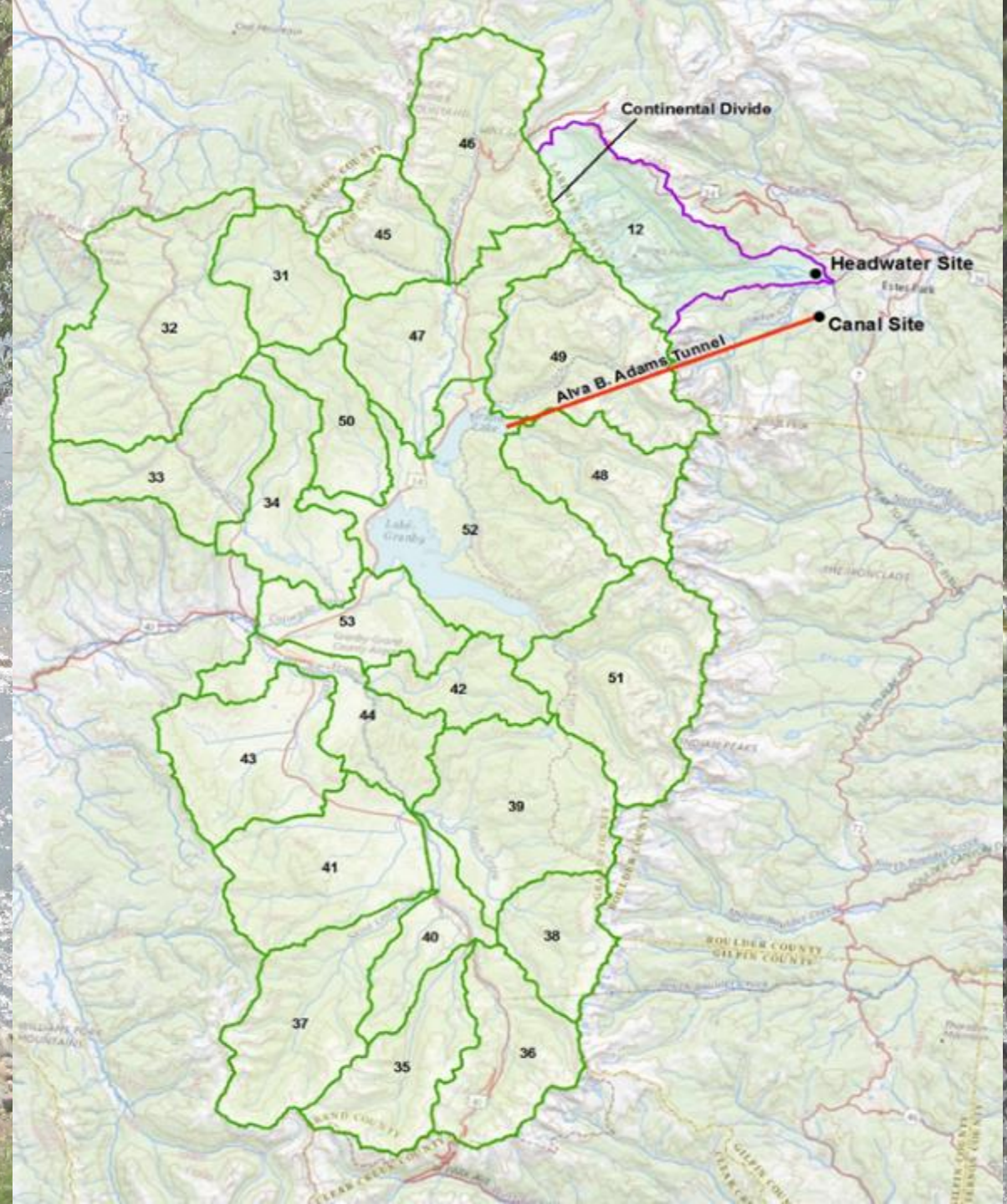
303d Copper Impairment

- Dissolved copper levels are generally low (~1-2 ug/L) in impaired segments of the Big Thompson River but impairment level is based on hardness
- Hardness is also low (~7-10 mg/L) so level of dissolved copper needed for impairment is low.

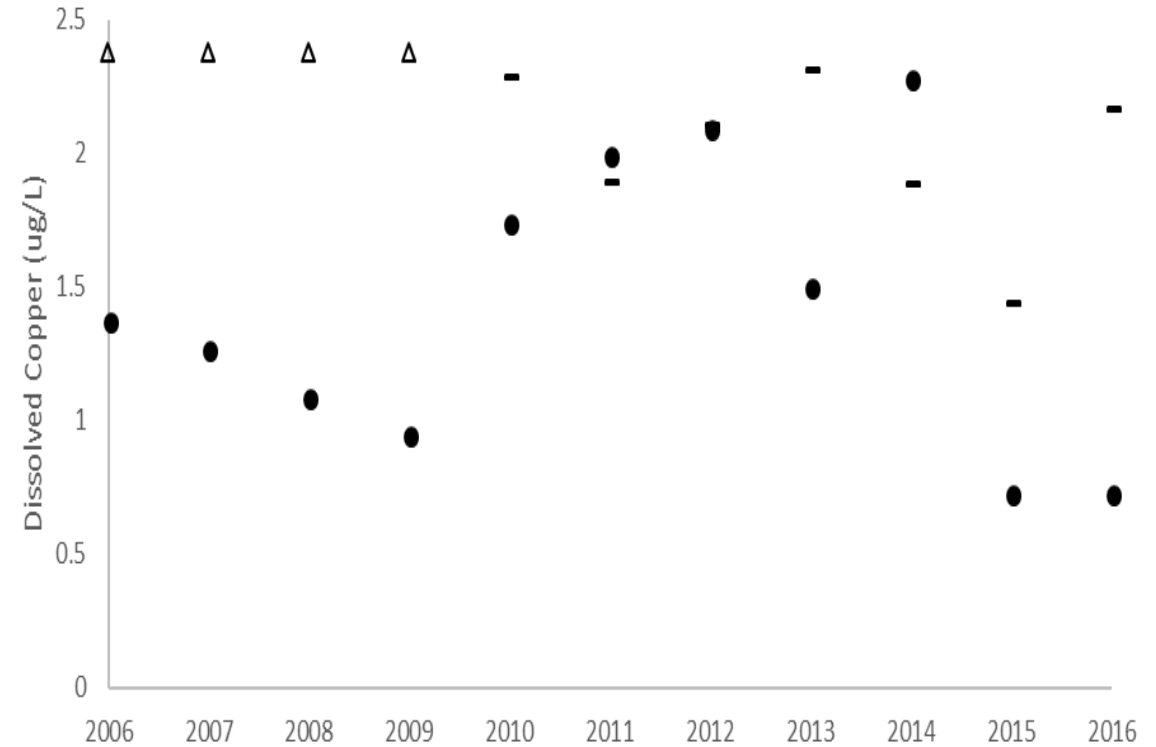
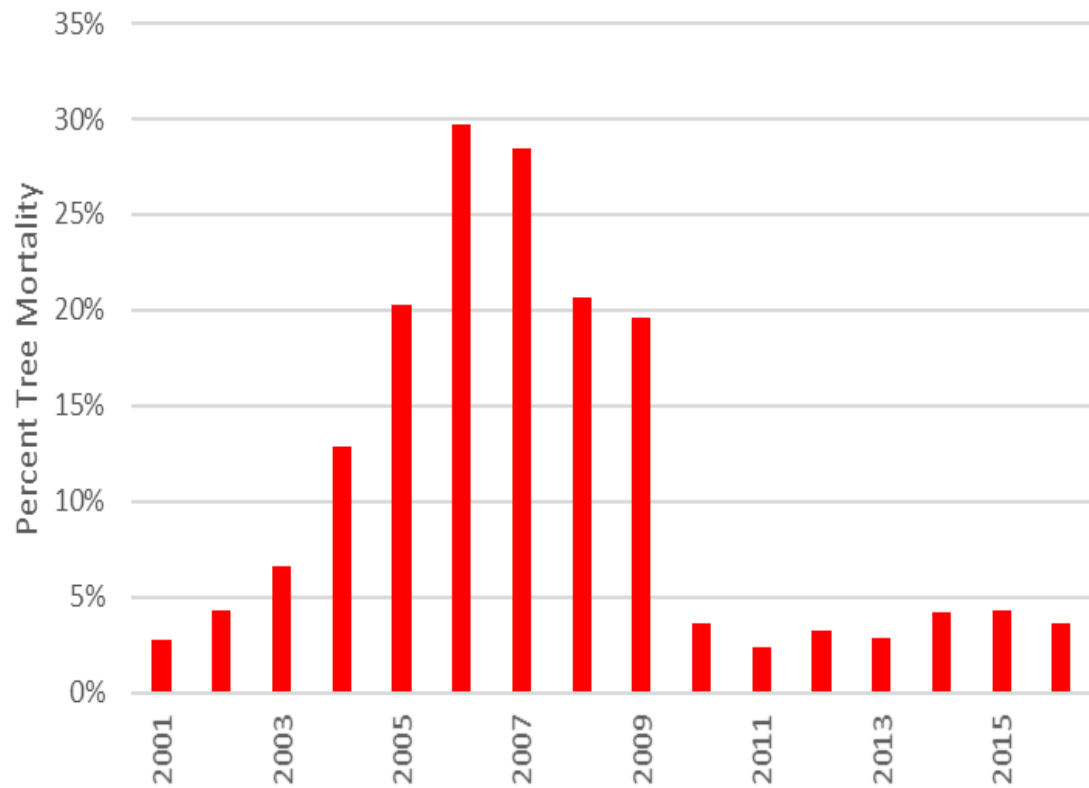
➤ Acute Copper Impairment = $e^{(0.9422(\ln(\text{Hardness}))-1.7408)}$

Sampling Locations

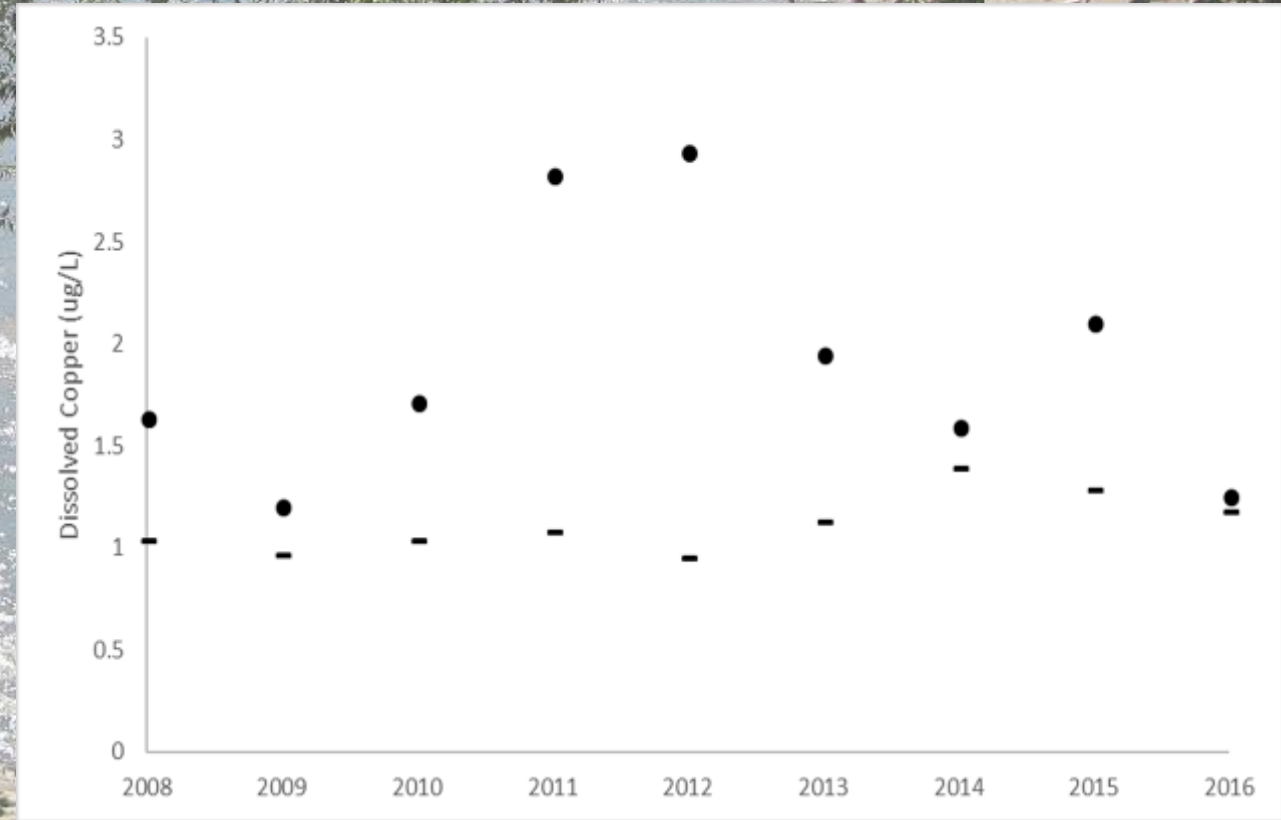
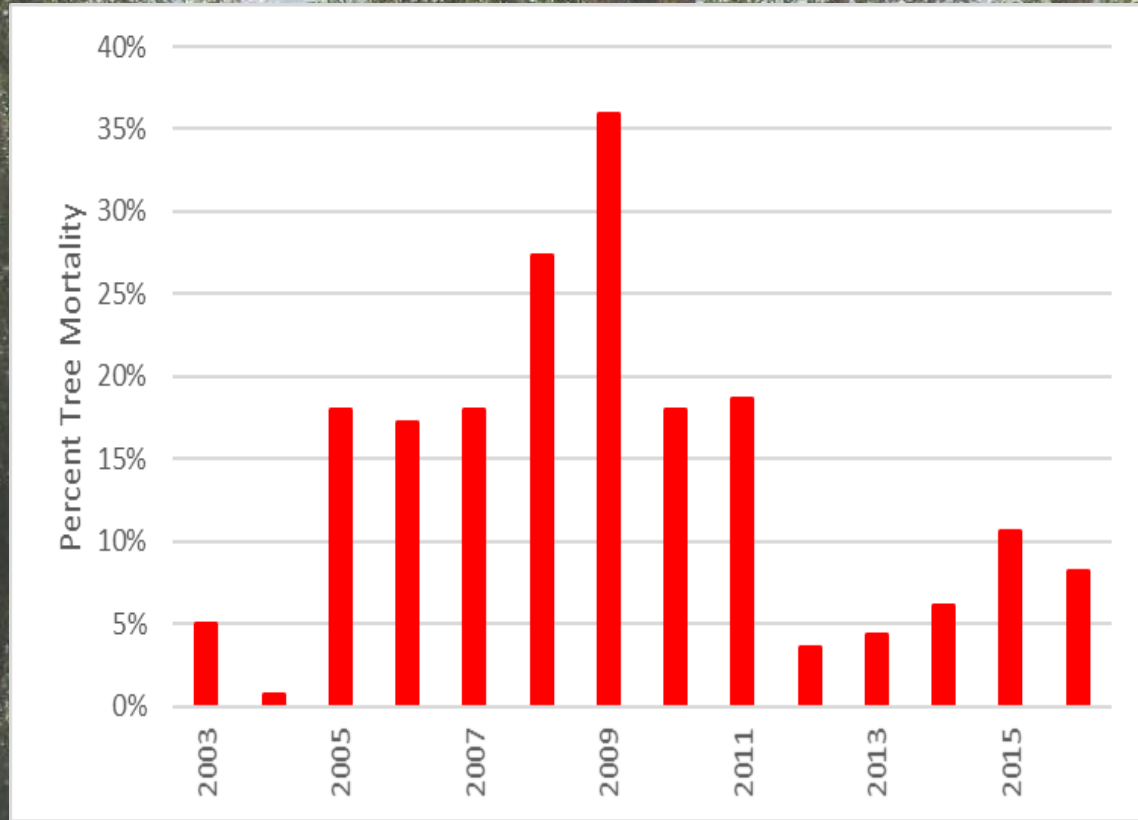
- **Headwater Site:** Eastern slope
- **Canal Site:** Western Slope via the Adams Tunnel



Percent Tree Mortality and Dissolved Copper Levels: Canal Site



Percent Tree Mortality and Dissolved Copper Levels: Headwater Site



Methods

- Dissolved copper values sampled monthly 2001-2016 at the canal site and 2008-2016 at the headwater site.
- Percent tree mortality available 1997-2016
- Potential time lags included were based on a cross-correlation function in R
- Relationship between dissolved copper and percent tree mortality investigated using a generalized linear model and lags up to and including 5 years
 - Model selection was determined using all possible combinations of variables (“bestglm” function in R) and BIC.
 - Predictor variables were also removed if they improved the BIC but were not significant at $p = 0.05$.

Results

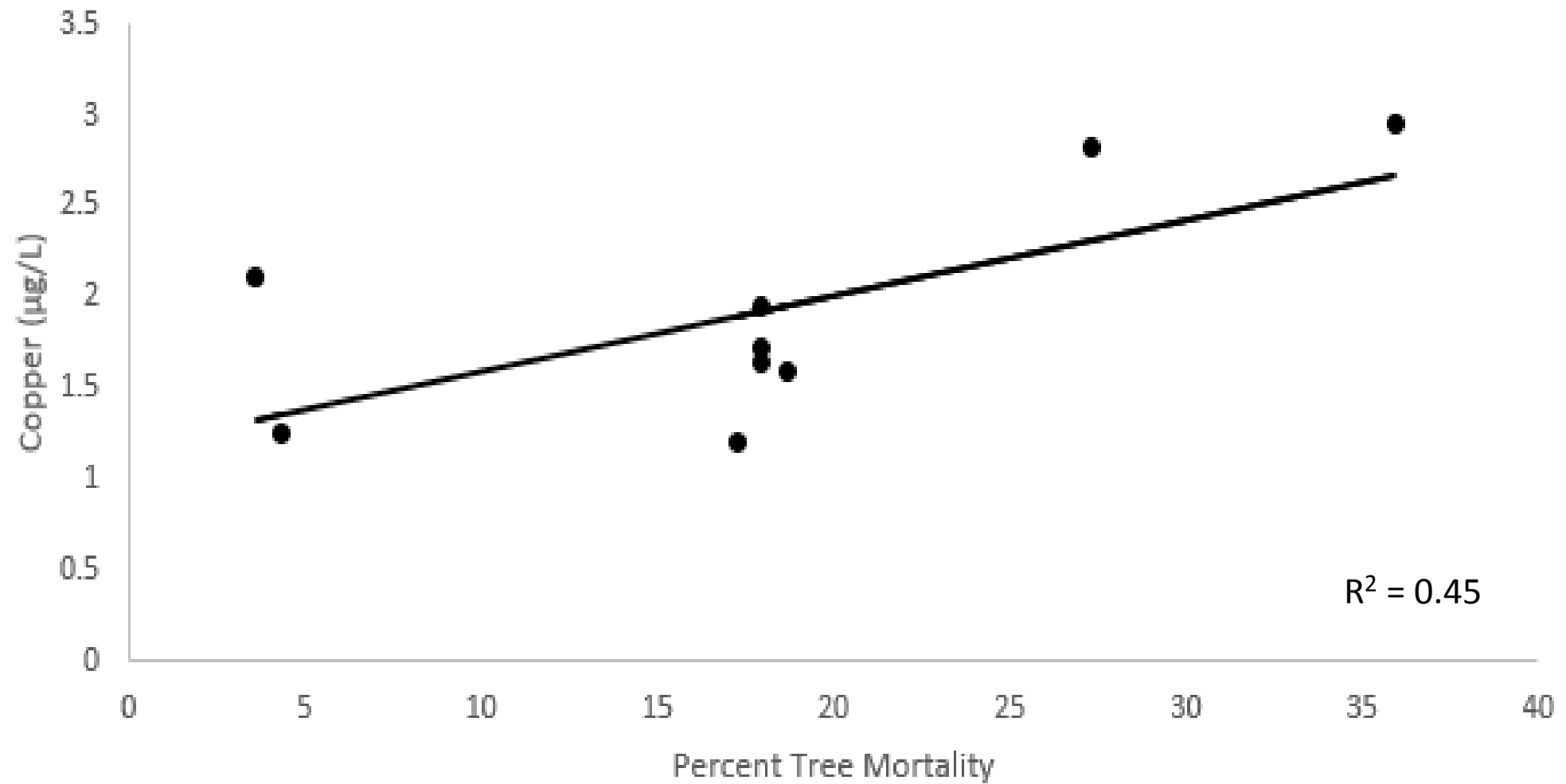
- Headwater Site

- Dissolved copper = $1.1727 + 4.1749 * \text{Lag of three years percent tree mortality}$

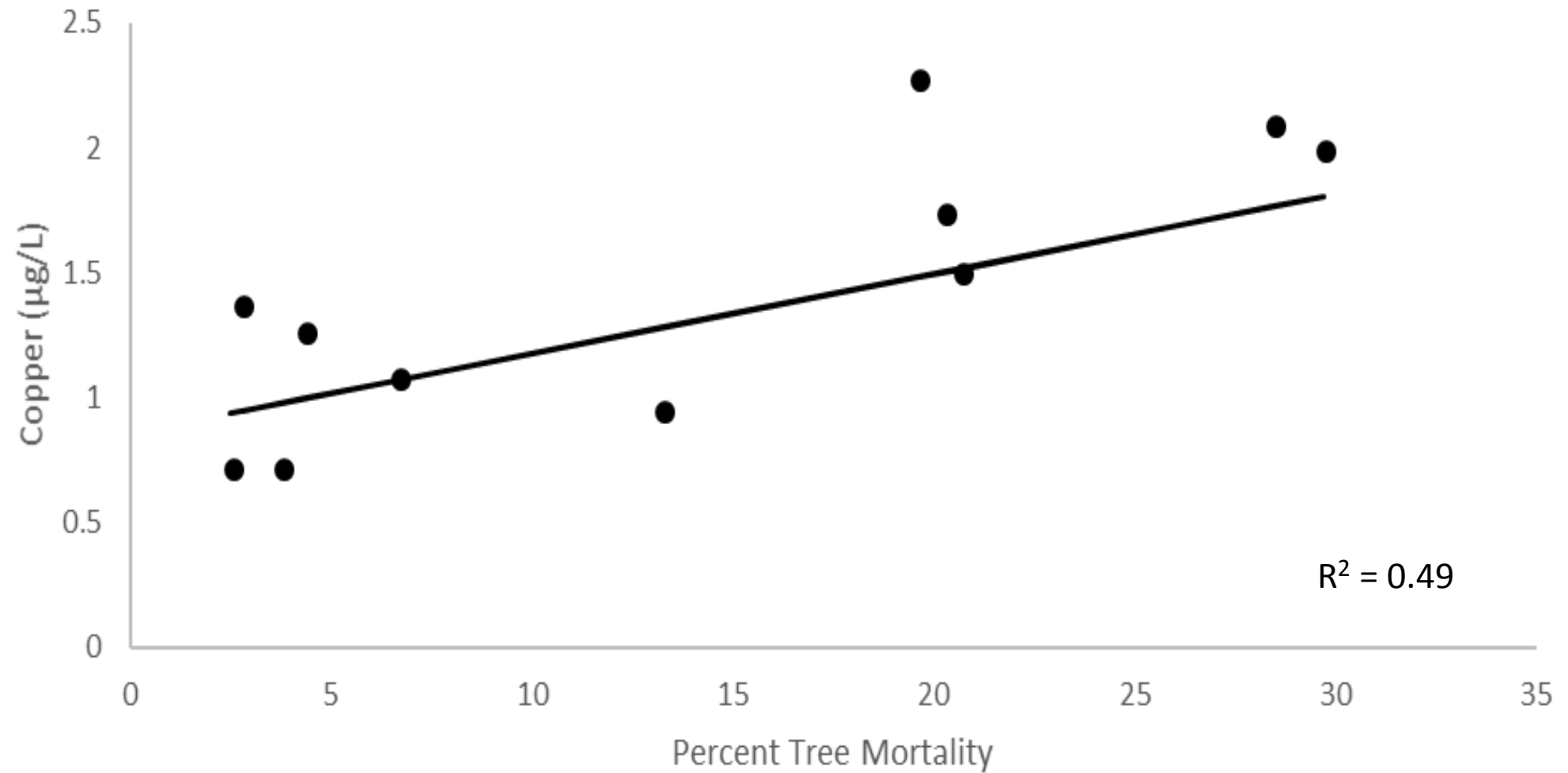
- Canal Site

- Dissolved copper = $0.8606 + 3.6555 * \text{Lag of five years percent tree mortality}$

Headwater Site



Canal Site



Conclusions

- Tree mortality is associated with in-river dissolved copper levels
- Lag between tree mortality and dissolved copper levels is 3-5 years in the Big Thompson River.
- Lag may depend on soil type and dissolved organic carbon.
 - Increased copper mobility can be associated with higher levels of organic carbon (Zhou and Wong 2001; Han and Thompson 2003).
 - Soil composition differs between the eastern and western side of the continental divide, with the eastern side containing a higher amount of total carbon in the soil (Rueth and Baron 2002).
 - Higher dissolved organic carbon = shorter lag?
- Continuing declines in tree mortality may result in lower dissolved copper levels.



Photo Credit: Laurie Schmidt BTWF

Acknowledgements

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